WHAT IS CLAIMED IS:

1. A crystallization apparatus which comprises an optical illumination system to emit a light beam onto a non-crystallized semiconductor film and which irradiates the non-crystallized semiconductor film with the light beam to crystallize the non-crystallized semiconductor film, the apparatus comprising:

a wavefront dividing element which wavefront-divides the incident light beam into a plurality of light beams; and

a phase shift mask which has a phase shift portion gives a predetermined phase difference between to light beams from the wavefront driving element and converts the light beams into a light beam having an inverse peak type light intensity distribution, the phase shift portion determining a position of the inverse peak type light intensity distribution where a light intensity is minimized,

the wavefront dividing element being positioned on a light path between the optical illumination system and the non-crystallized semiconductor film, the phase shift mask being positioned on the light path between the wavefront dividing element and the non-crystallized semiconductor film, and the wavefront dividing element and the phase shift mask being positioned so that a predetermined region around the phase shift portion is irradiated with the wavefront-divided light beams.

2. The crystallization apparatus according to claim 1, wherein the wavefront dividing element comprises a plurality of optical elements two-dimensionally arranged along two directions crossing at right angles to each other, and each optical element has a two-dimensional condensing function along two directions crossing at right angles to each other.

3. The crystallization apparatus according to claim 1, wherein the wavefront dividing element comprises a plurality of optical elements one-dimensionally arranged along a predetermined direction, and each optical element has a one-dimensional condensing function along the predetermined direction.

4. The crystallization apparatus according to claim 1, wherein the optical illumination system comprises an light intensity distribution forming element which converts the light beams having the homogeneous light intensity distribution into light beams having an upward concave light intensity distribution in combination with the wavefront dividing element,

the light intensity distribution forming element and the phase shift mask are positioned so that a position to minimize the upward concave light intensity distribution may correspond to the phase shift portion, and

the light beam which are converted by the light

intensity distribution forming element and the phase shift mask and with which the non-crystallized semiconductor film is irradiated has an light intensity distribution having an inverse peak portion inside an upward concave portion.

5. The crystallization apparatus according to claim 4, wherein the light intensity distribution forming element comprises: a circular middle region having a transmittance; and an annular peripheral region which is formed to surround the middle region and which has a higher transmittance than the middle region.

6. The crystallization apparatus according to claim 4, wherein the light intensity distribution forming element comprises: an elongated middle region which has a transmittance and which extends along one direction; and two peripheral regions which are formed to hold the middle region between the regions and which have a transmittance higher than that of the middle region.

7. The crystallization apparatus according to claim 4, wherein the light intensity distribution forming element has a transmission filter which is disposed in an emission pupil plane of the optical illumination system or in the vicinity of the plane and which has a predetermined transmittance distribution.

8. The crystallization apparatus according to

claim 1, wherein the non-crystallized semiconductor film is disposed in parallel with and in the vicinity of the phase shift mask.

9. The crystallization apparatus according to claim 1, wherein the optical illumination system and the wavefront dividing element have numerical apertures and focal distances satisfying the following conditions:

$\lambda/NA2 < f \times NA1$,

where NA1 denotes the numerical aperture of the optical illumination system, NA2 and f denote the numerical aperture and focal distance of the wavefront dividing element, and λ denotes a wavelength of the light beam.

10. The crystallization apparatus according to claim 1, further comprising:

an optical image forming system which is disposed on the light path between the non-crystallized semiconductor film and the phase shift mask,

wherein the non-crystallized semiconductor film is disposed apart from a plane optically conjugated with the phase shift mask along an optical axis of the optical image forming system.

11. The crystallization apparatus according to claim 1, further comprising:

an optical image forming system positioned on the light path between the non-crystallized semiconductor film and the phase shift mask,

wherein the non-crystallized semiconductor film is set in a plane optically conjugated with the phase shift mask, and

an image-side numerical aperture of the optical image forming system is set so as to form the inverse peak type light intensity distribution.

12. The crystallization apparatus according to claim 10 or 11, which satisfies the following conditions:

$\lambda/NA2 < f \times NA1$; and

$\lambda/NA3 < f \times NA1$,

where NA1 denotes a numerical aperture of the optical illumination system, f denotes a focal distance of the wavefront dividing element, NA2 denotes the numerical aperture of the wavefront dividing element, λ denotes a wavelength of the light beam, and NA3 denotes an image-side numerical aperture of the optical image forming system.

13. The crystallization apparatus according to claim 4, wherein the light intensity distribution of the light beam with which the non-crystallized semiconductor film is irradiated has an inflection point between an inverse peak portion and an upward concave portion.

14. The crystallization apparatus according to claim 1, wherein the wavefront dividing element is formed integrally with the phase shift mask to provide

an integral assembly.

15. The crystallization apparatus according to claim 14, wherein the integral assembly includes a phase shift portion in a boundary surface between the wavefront dividing element and the phase shift mask.

16. An optical member comprising:

a wavefront dividing portion which condenses a light beam having a homogeneous incident light intensity distribution so as to irradiate a predetermined region only; and

an optical converting portion which converts the incident light beam into a light beam having an inverse peak type light intensity distribution.

17. The optical member according to claim 16, wherein the wavefront dividing portion is integrally formed with the optical converting portion.

18. A crystallization method comprising:

wavefront-dividing an incident light beam into a plurality of light beams;

condensing the wavefront-divided light beams in a corresponding phase shift portion of a phase shift mask or in the vicinity of the phase shift portion to form a light beam having an light intensity distribution of an inverse peak pattern in which a light intensity is minimum in a point corresponding to the phase shift portion of the phase shift mask; and

irradiating a polycrystalline semiconductor film

or an amorphous semiconductor film with the light beam having the light intensity distribution to produce a crystallized semiconductor film.

19. The crystallization method according to claim 18, further comprising:

forming the light intensity distribution in which the light intensity is high in a periphery rather in a middle in an illumination pupil plane of an optical illumination system which emits the wavefront-divided light beams.

20. The crystallization method according to claim 18, further comprising:

disposing the polycrystalline semiconductor film or the amorphous semiconductor film in parallel with or in the vicinity of the phase shift mask.

21. The crystallization method according to claim 18, further comprising:

disposing an optical image forming system in a light path between the polycrystalline semiconductor film or the amorphous semiconductor film and the phase shift mask; and

setting the polycrystalline semiconductor film or the amorphous semiconductor film apart from a plane optically conjugated with the phase shift mask by a predetermined distance along an optical axis of the optical image forming system.

22. The crystallization method according to

claim 18, further comprising:

disposing an optical image forming system in a light path between the polycrystalline semiconductor film or the amorphous semiconductor film and the phase shift mask;

setting an image-side numerical aperture of the optical image forming system to a value required for generating the light intensity distribution of the inverse peak pattern; and

setting the polycrystalline semiconductor film or the amorphous semiconductor film in a plane optically conjugated with the phase shift mask.

23. A crystallization method comprising:

condensing a light beam having a homogeneous light intensity distribution so as to irradiate a predetermined region only;

converting the condensed light beam into a light beam having an inverse peak type light intensity distribution; and

irradiating and crystallizing the predetermined region only of a non-crystallized semiconductor film with the converted light beam.

24. The crystallization method according to claim 23, further comprising: converting the light beam having the inverse peak type light intensity distribution to a light beam having an light intensity distribution including an inverse peak portion inside

an upward concave portion.

25. The crystallization method according to claim 23, further comprising:

forming the light beam having the light intensity distribution including the inverse peak portion inside the upward concave portion into an image in a position disposed apart from an optically conjugated plane along an optical axis; and

irradiating and crystallizing the non-crystallized semiconductor film with the light beam formed into the image.

26. A crystallization apparatus comprising:

a light source which emits an energy light having a light intensity to melt a semiconductor layer to be treated;

a filter which is disposed on an illuminative light path from the light source and which includes portions having different transmittance;

a wavefront dividing element disposed on an emission light path of the filter;

a phase shift mask disposed on the emission light path of the wavefront dividing element; and

a stage which is disposed on the emission light path of the phase shift mask and which holds a substrate including the semiconductor layer to be treated.

27. A crystallization apparatus comprising:

a light source which emits an energy light having a light intensity to melt a semiconductor layer to be treated;

a filter which is disposed on an illuminative light path from the light source and which includes portions having different transmittance;

a wavefront dividing element disposed on an emission light path of the filter; and

a stage which is disposed on the emission light path of the wavefront dividing element and which holds a substrate including the semiconductor layer to be treated.

28. A crystallization apparatus comprising:

a light source which emits an energy light having a light intensity to melt a semiconductor layer to be treated;

a wavefront dividing element disposed on an emission light path from the light source;

a phase shift mask disposed on the emission light path of the wavefront dividing element; and

a stage which is disposed on the emission light path of the phase shift mask and which holds a substrate including the semiconductor layer to be treated.

29. A crystallization method comprising:

allowing an energy light having a light intensity to melt a semiconductor layer to be treated to be

incident upon a mask having portions different in transmittance from a light source;

allowing the energy light from the mask to be incident upon a wavefront dividing element which divides the energy light into a plurality of energy light parts and emitting a plurality of converged energy light parts;

allowing the plurality of converged energy light parts to be incident upon a phase shift mask having a portion different in phase by 180 degrees from the wavefront dividing element and emitting an energy light having a concave light intensity distribution; and

allowing the energy light having the light intensity distribution to be incident upon the semiconductor layer to be treated.

30. A crystallization method comprising:

a step of allowing an energy light having a light intensity to melt a semiconductor layer to be treated to be incident upon a mask having portions different in transmittance from a light source;

a step of allowing the energy light transmitted through the mask to be incident upon a wavefront dividing element which divides the energy light into a plurality of converged energy lights parts; and

allowing the energy light parts transmitted through the wavefront dividing element to be incident upon the semiconductor layer to be treated.

31. A crystallization method comprising:

allowing an energy light transmitted through a phase shift mask to be incident upon a non-crystalline semiconductor layer to crystallize the layer,

wherein the energy light incident upon the phase shift mask is a light transmitted through a mask having a portion different in a transmittance.

32. A crystallization method comprising:

allowing an energy light transmitted through a phase shift mask to be incident upon a non-single-crystal semiconductor layer to crystallize the layer,

wherein an light intensity distribution of a light beam incident upon the non-single-crystal semiconductor layer is a two-steps inverse peak type light intensity distribution in which a further linearly rising concave light intensity distribution is superimposed upon an upper end of an inverse peak type light intensity distribution waveform indicating an light intensity distribution property of the phase shift mask.

33. A manufacturing method of a thin film transistor, comprising:

forming a polycrystalline semiconductor film or an amorphous semiconductor film on one side of a substrate;

wavefront-dividing an incident light beam into a plurality of light beams;

condensing the wavefront-divided light beams in

a corresponding phase shift portion of a phase shift mask or in the vicinity of corresponding portion to form a light beam having an light intensity distribution of an inverse peak pattern in which a light intensity is minimum in a point of the corresponding phase shift portion of the phase shift mask;

irradiating the polycrystalline semiconductor film or the amorphous semiconductor film with the light beams having the light intensity distribution to produce a crystallized semiconductor film;

successively forming a gate insulation film and a gate electrode on the crystallized semiconductor film;

forming a drain and source between which a channel is positioned in the crystallized semiconductor film; and

forming a drain electrode and source electrode electrically connected to on the drain and source.

34. The manufacturing method of the thin film transistor according to claim 33, wherein the generating of the crystallized semiconductor film comprises: laterally growing and generating the crystallized semiconductor film in a direction having a large light intensity gradient from a crystal nucleus to form the source and drain along the direction.

35. A manufacturing method of a matrix circuit substrate, comprising:

forming a polycrystalline semiconductor film or

an amorphous semiconductor film on one side of a transparent substrate;

wavefront-dividing an incident light beam into a plurality of light beams;

condensing the wavefront-divided light beams in a corresponding phase shift portion of a phase shift mask or in the vicinity of the portion to form a light beam having an light intensity distribution including an inverse peak pattern in which a light intensity is minimum in a point corresponding to the phase shift portion of the phase shift mask;

irradiating the polycrystalline semiconductor film or the amorphous semiconductor film with the light beam having the light intensity distribution to produce a crystallized semiconductor film;

separating the crystallized semiconductor film into a large number of portions positioned in a matrix shape;

forming thin film transistors based on the separated portions; and

forming pixel electrodes on one side of the transparent substrate so that each pixel electrode is electrically connected to each thin film transistor to define a pixel.

36. The manufacturing method according to claim 35, wherein the generating of the crystallized semiconductor film comprises: forming a light beam

having an light intensity distribution including a large number of inverse peak patterns apart from one another; and irradiating the polycrystalline semiconductor film or the amorphous semiconductor film with the light beam so that an interval between the inverse peak patterns agrees with that between the pixels.